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AN UNUSUAL OCCURRENCE OF ALBITE

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On a visit made several months ago to the trap-rock quarries in the western part of Paterson, New Jersey, two specimens were found, carrying a mineral of different appearance from the zeolites and associated minerals of usual occurrence there.

The quarry from which the specimens were obtained is the western one of the two openings near the Delaware, Lackawanna, and Western Railroad. The site is well known to mineralogists; many beautiful specimens of zeolites, pectolite, prehnite, datolite, apophyllite, thaumasite and other species have been obtained there, and are found in mineral collections throughout the country.

The specimens suggested albite, and further investigation has confirmed this, but certain features of the occurrence are unusual, not only as regards the mineral associations in the Watchung basalt, but with respect to the occurrence of albite in general.

The relations appear in the accompanying photograph. The crystals occupy a vug or cavity in slightly altered basalt. The cavity probably represents a pocket left between portions of adjacent "pillows" of the lava flow, later somewhat modified by solution and mineral deposition. Such spaces are favorite sites of deposition of secondary minerals in the Watchung basalt, probably due partly to their having offered channels of relatively easy circulation for solutions, and also because the tachylitic crusts of the "pillows" were more easily attacked and worked over than was the densely crystalline phase of the basalt.

In the figure, the portion designated 1 is nearly pure albite, forming a continuous crust or lining of the cavity, and with small terminated crystals projecting into the free space; 2 is calcite, 3 is chabazite, and 4 is prehnite. Albite is evidently the oldest of these minerals.

The second specimen, which was broken up to obtain material for analysis, was very similar, but in one part a mass of prehnite showed one of the well-known cavities or molds formerly occupied by a mineral which has now disappeared. Probably such cavities represent more than one species of mineral; in this case the shape suggests anhydrite, of which occasional specimens have been found here in good preservation. Imbedded in the prehnite, and also resting upon it, were minute clusters of dark-green amphibole. There were also a few small crystals of the rare mineral babingtonite, which is known to occur in this locality and is easily diagnosed by the intense and highly characteristic pleochroism of its powder in polarized light. Scattered small spots of ashy-green, earthy material seen here and there may be a decomposition product of babingtonite. These minerals all appear to be younger than the albite.

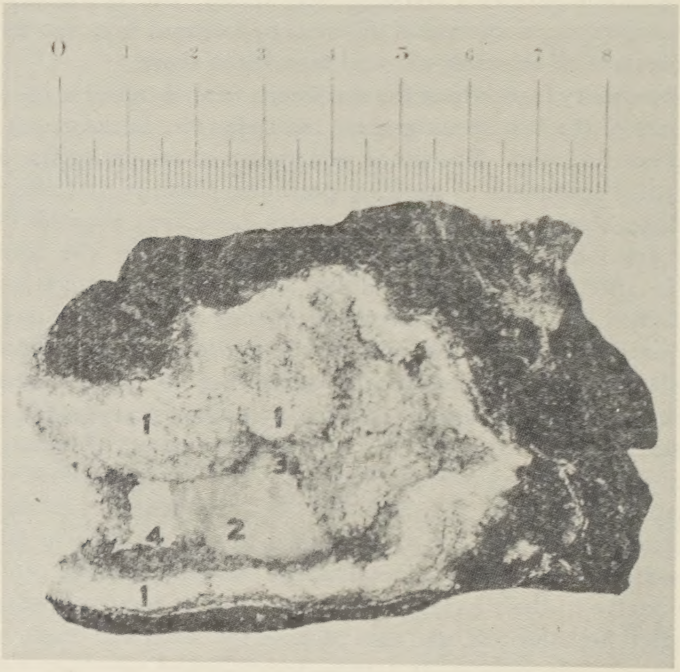

Figure 1
Albite lining cavity in Watchung basalt. 1=albite, 2=calcite, 3=chabazite, 4=prehnite. Scale in centimeters.

The free ends of the albite crystals attain an ordinary maximum length of 1 to 1½mm. They were examined with the idea of selecting some for goniometric measurement, but the faces hardly appeared well enough developed for the purpose, and some were curved. With a binocular magnifier, however, it was possible to recognize a number of the forms. The habit of the crystals is rather unusual. They are elongated in the direction of the $\breve{a}$ axis, and tabular parallel to the side pinacoid $b(010)$. The orientation was determined by the plane of perfect cleavage parallel to the base, and confirmed by the position of the plane of albite twinning.

The side pinacoid, (010), is vertically striated, and in most cases is slightly curved. Other recognizable faces are the base $c(001)$ and the prisms $m(110)$ and $M(1\bar{1}0)$. Less certain are a brachydome, perhaps $n(0\bar{2}1)$, and a second prism, perhaps $f(130)$. There is also a macrodome, probably $x(\bar{1}01)$. The intersection of this dome and of the base with the side pinacoid gives the crystals an elongated rhombic outline, with the tips of the acute angles cut off by the prism faces.

Preliminary tests upon the mineral gave a hardness of about 6, and showed that its powder was not acted upon by warm 1 : 1 HCl.

Under the microscope, it was found to be biaxial, positive, with a large axial angle; $\alpha = 1.530$, $\gamma > 1.535 < 1.540$.

Polysynthetic twinning, resembling closely that of albite, was evident, and maximum extinction angles on symmetrically extinguishing twins gave, in three cases, 15½°, 15½°, and 17°.

These results agreed satisfactorily with albite, but in order to settle all doubts an analysis was made. One of the specimens was broken up, and the pieces were immersed for several hours in cold dilute (1 : 3) HCl to remove calcite. Small pieces of the crusts were then examined individually under a binocular magnifier, and the albite was picked out. Prehnite was the only mineral in close enough association with the albite to give trouble. All pieces showing recognizable prehnite were rejected; this necessitated the rejection of much material, as some of the crusts which were nearly pure albite contained a little closely adhering prehnite. The finally selected material appeared, under the binocular, to be pure albite except for a minute quantity of the earthy green substance previously mentioned. When the powder was examined microscopically there was an occasional grain of prehnite to be seen. As a rough guess, the amount was set down as 1 to 2 percent. Otherwise the albite showed no contamination, but in liquid of index 1.530 it appeared slightly turbid.

The color, both in the hand specimen and in the powder, was a pale salmon-pink, almost white; luster dull on compact surfaces, vitreous or shining on crystal faces and basal cleavages.

The analysis was performed according to standard methods. The usual precautions of evaporating twice for SiO_2, and making two precipitations of Al_2O_3, CaO, and MgO were observed. The results follow:

SiO_2	67.99
Al_2O_3	19.45
Fe_2O_3	0.22
MgO	0.20
CaO	0.37
Na_2O	11.01
K_2O	0.39
H_2O	0.40
	100.03

As a little prehnite was visibly present, the CaO was calculated to prehnite, and found to correspond to 1.36 per cent. The corresponding amounts of Al_2O_3 and SiO_2 were deducted from the analysis, and also Fe_2O_3, MgO, and H_2O; K_2O was calculated to its equivalent in Na_2O, and added to the Na_2O found; SiO_2, Al_2O_3, and Na_2O were then recalculated to 100 per cent. The results, compared with the theoretical composition of albite, are:

	FOUND BY ANALYSIS	THEORETICAL COMPOSITION OF ALBITE
SiO_2	68.87	68.75
Al_2O_3	19.53	19.44
Na_2O	11.60	11.81

The agreement is so close that there can hardly be doubt that the mineral is albite containing little or no anorthite and only a very small amount of the orthoclase molecule. The feldspars of the unaltered basalt are commonly labradorite, and recorded analyses show one-half to one-sixth as much potash as soda in the basalt, but in the formation of the secondary feldspar both lime and potash have been nearly eliminated.

In a study of the zeolites and associated minerals of the Watchung basalt, made by the writer several years ago,[1] scattered occurrences of small amounts of albite were discovered by microscopic examination of specimens. Its relations indicated that in the long series of paragenetic transformations of these minerals it was one of the first to be formed, but was later replaced by others. It was thought not improbable that a large amount of albite might have appeared among the first products, but that little of it survived. In more recent years the finding of occasional specimens of albite has been reported by collectors, but no description appears to have been given in the literature. The discovery of such specimens seems to support the view expressed in the earlier article.

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[1] C. N. Fenner: The Watchung basalt and the paragenesis of its zeolites and other secondary minerals, *An. N. Y. Acad. Sci.*, 20, No. 2, part 2. pp. 93-187, Aug., 1910.

SOME FACTORS INFLUENCING CRYSTAL HABIT

(Concluded)

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B. CRYSTALS FORMED IN AQUEOUS SOLUTIONS CONTAINING ONE FOREIGN SUBSTANCE

(Continued from page 239)

To determine the effect of foreign substances, or impurities, on crystal habit a series of experiments was carried out testing the influence of a number of inorganic salts which differ somewhat in solubility. Also, some organic substances were used as impurities. Some insoluble substances reduced to a very fine powder were likewise used as suspensions. The experiments in which inorganic salts were used as impurities will be described first.

Experiments were conducted with the same three salts listed under A, viz: lead nitrate, barium nitrate, and strontium nitrate. Four different conditions for crystal growth were employed:

1. Evaporation "medium"; temperature 20°C to 24°C.
2. Evaporation "medium"; temperature 25°C to 30°C.
3. Evaporation "slow"; temperature 20°C to 24°C.
4. Evaporation "slow"; temperature 25°C to 30°C.

Observations for record were made after 12 hours, 36 hours, and 60 hours of crystal growth. Experiments were conducted in the same manner as under A. The results obtained from a few experiments will be briefly described in the following pages. Other results from a number of these experiments using inorganic salts as impurities will be tabulated in table No. III.

It was found that within certain limits, the result obtained was influenced by the amount of impurity added. In order, therefore, to make comparisons more valuable, equivalent amounts of the impurities were used.

Barium nitrate was added as an impurity to a solution of lead nitrate. Because of its low solubility the amount employed was not equivalent to that of the other salts used. The amount of barium nitrate added was the amount necessary to make a 1/7 normal solution. For all other salts, unless otherwise indicated, an amount sufficient for a 2/5 normal solution was used. For the sake of making comparisons it was found that results were more consistent and more pronounced by using that amount or more. Appreciable results were obtained by adding the amounts required for a 1/10 normal solution.

LEAD NITRATE+SILVER NITRATE
Evaporation "medium"
Temperature 25°C to 30°C

All the crystals that were first formed under these conditions were combinations of ± tetrahedrons, about equally developed. After 12 hours of crystal growth some of the crystals began to show a small pyritohedron in combination with the ± tetrahedrons and as crystal growth was allowed to continue the pyritohedrons steadily increased in number and also became relatively larger. The tetrahedrons, however, remained the dominant forms.

If this experiment is performed at temperatures of 20°C to 24°C it will be found that for the first 12 hours the same results are obtained as with temperatures of 25°C to 30°C. As crystal growth is allowed to continue under temperature conditions of 20°C to 30°C the form to appear first in combination with the ± tetrahedrons is the cube. If the process of crystal growth continues for 10 or 15 hours, after the cube has entered into combination with the majority of the crystals, the pyritohedron may develop on a small percent of crystals as a very subordinate form.

LEAD NITRATE+SILVER NITRATE
Evaporation "slow"
Temperature 25°C to 30°C.

Crystals first started under conditions of "medium" evaporation are transferred to conditions of "slow" evaporation. The crystals first formed are combinations of ± tetrahedrons. In a few hours after changing from "medium" conditions to "slow" conditions of evaporation, the crystals become more complex and after 36 hours of crystal growth the pyritohedron is relatively larger than for the same period of time under conditions of "medium" evaporation. The cube is present as a subordinate form on a small percent of crystals. After 60 hours of crystal growth the pyritohedron has increased in relative size.

By comparing these results with those obtained when lead nitrate crystals are grown in pure aqueous solutions a pronounced contrast may readily be noted. For the same conditions of evaporation and temperature there is a decided tendency for the crystals, of the experiment just described, to be more simple in habit than crystals from pure aqueous solutions. The tendency for crystals of simple habit to form is stronger during the first 12 hours of crystal growth than for a longer period of growth. After 60 hours, the crystals from aqueous solutions, with silver nitrate as an impurity, become as complex as those from pure aqueous solutions. The complex forms from pure aqueous solutions, however, occur in relatively higher percent.

The presence of silver nitrate in solutions of barium nitrate or strontium nitrate has qualitatively the same effect on the habit of the crystals obtained as in the case of lead nitrate.

If crystal growth is allowed to continue for 60 hours or more, the crystals in the liquor gradually become more complex in habit. The crystals finally obtained under conditions of "slow" evaporation and at temperatures between 25°C and 30°C are as complex as those obtained from pure aqueous solutions under the same conditions and for the same period of crystal growth.

Table No. III

Lead nitrate; Evaporation "medium"; Temperature 20°C to 24°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$AgNO_3$	12	±(111) 100%	Equally developed
$AgNO_3$	36	±(111) . . . . 75% ±(111), (100) 25%	±(111) 100%
$AgNO_3$	60	±(111) . . . . 60% ±(111), (100) 40%	±(111) . . . . 75% (100) 25%
NH_4NO_3	12	±(111) 100%	Equally developed
NH_4NO_3	36	±(111) . . . . 63% ±(111), (100) 37%	±(111) 100%
NH_4NO_3	60	±(111) . . . . 60% ±(111), (100) 40%	±(111) . . . . 80% (100) 20%
$Ca(NO_3)_2$	12	±(111) 100%	Equally developed
$Ca(NO_3)_2$	36	±(111) . . . . 60% ±(111), (100) 40%	±(111) 100%
$Ca(NO_3)_2$	60	±(111) . . . . 55% ±(111), (100) 45%	±(111) . . . . 67% (100) 33%
$Cu(NO_3)_2$	12	±(111) . . . . 95% ±(111), (100) 5%	±(111) 100%
$Cu(NO_3)_2$	36	±(111) . . . . 50% ±(111), (100) 50%	±(111) 100%
$Cu(NO_3)_2$	60	±(111) . . . . 48% ±(111), (100) 52%	±(111) . . . . 60% (100) 40%

Lead nitrate; Evaporation "medium"; Temperature 20°C to 24°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$NaNO_3$	12	±(111)............100%	Equally developed
$NaNO_3$	36	±(111)............ 75% ±(111), (100)....... 25%	±(111)..........100%
$NaNO_3$	60	±(111)............ 68% ±(111), (100)....... 32%	±(111).......... 90% (100).......... 10%
$Mg(NO_3)_2$	12	±(111)............ 85% ±(111), (100)....... 15%	±(111)..........100%
$Mg(NO_3)_2$	36	±(111)............ 80% ±(111), (100)....... 20%	±(111).......... 93% (100).......... 7%
$Mg(NO_3)_2$	60	±(111)............ 75% ±(111), (100)....... 25%	±(111).......... 88% (100).......... 12%
$LiNO_3$	12	±(111)............100%	Equally developed
$LiNO_3$	36	±(111)............ 82% ±(111), (100)....... 18%	±(111)..........100%
$LiNO_3$	60	±(111)............ 30% ±(111), (100)....... 70%	±(111).......... 80% (100).......... 20%
KNO_3	12	±(111)............ 80% ±(111), (100)....... 20%	±(111)..........100%
KNO_3	36	±(111)............ 65% ±(111), (100)....... 35%	±(111)..........100%
KNO_3	60	±(111)............ 35% ±(111), (100)....... 65%	±(111).......... 78% (100).......... 22%
$Ba(NO_3)_2$	12	±(111)............ 30% ±(111), (100)....... 70%	±(111).......... 85% (100).......... 15%
$Ba(NO_3)_2$	36	±(111)............ 28% ±(111), (100)....... 72%	±(111).......... 83% (100).......... 17%
$Ba(NO_3)_2$	60	±(111)............ 20% ±(111), (100)....... 80%	±(111).......... 80% (100).......... 20%

Lead nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$AgNO_3$	12	±(111)............ 80% ±(111), (100)....... 8% ±(111), (hko)....... 12%	±(111)..........100%
$AgNO_3$	36	±(111)............ 30% ±(111), (100)....... 30% ±(111), (hko)....... 40%	±(111)..........100%
$AgNO_3$	60	±(111)............ 18% ±(111), (100), (hko). 50% ±(111), (hko)....... 32%	±(111).......... 80% (100).......... 12% ±(111), (hko)..... 8%
NH_4NO_3	12	±(111)............ 83% ±(111), (100)....... 12% ±(111), (100), (hko). 5%	±(111)..........100%
NH_4NO_3	36	±(111)............ 13% ±(111), (100)....... 28% ±(111), (100), (hko). 59%	±(111).......... 90% (100).......... 3% ±(111), (hko)..... 7%
NH_4NO_3	60	±(111)............ 3% ±(111), (100)....... 35% ±(111), (hko)....... 12% ±(111), (100), (hko). 50%	±(111).......... 85% (100).......... 8% ±(111), (hko)..... 7%
$Ca(NO_3)_2$	12	±(111)............ 70% ±(111), (100)....... 12% ±(111), (100), (hko). 18%	±(111)..........100%
$Ca(NO_3)_2$	36	±(111)............ 7% ±(111), (100)....... 35% ±(111), (hko)....... 15% ±(111), (100), (hko). 43%	±(111).......... 87% (100).......... 5% ±(111), (hko)..... 8%
$Ca(NO_3)_2$	60	±(111)............ 5% ±(111), (100)....... 35% ±(111), (hko)....... 20% ±(111), (100), (hko). 40%	±(111).......... 75% (100).......... 10% ±(111), (hko)..... 15%

Lead nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$Cu(NO_3)_2$	12	±(111)............ 63% ±(111), (100)....... 18% ±(111), (hko)....... 7% ±(111), (100), (hko). 12%	±(111)..........100%
$Cu(NO_3)_2$	36	±(111)............ 10% ±(111), (100)....... 27% ±(111), (hko)....... 13% ±(111), (100), (hko). 50%	±(111).......... 80% (100).......... 8% ±(111), (hko)..... 12%
$Cu(NO_3)_2$	60	±(111)............ 0% ±(111), (100)....... 43% ±(111), (hko)....... 15% ±(111), (100), (hko). 42%	±(111).......... 68% (100).......... 18% ±(111), (hko)..... 14%
$NaNO_3$	12	±(111)............ 55% ±(111), (100)...... 30% ±(111), (hko)....... 7% ±(111), (100), (hko). 8%	±(111)..........100%
$NaNO_3$	36	±(111)............ 8% ±(111), (100)....... 32% ±(111), (hko)....... 8% ±(111), (100), (hko). 52%	±(111).......... 77% (100).......... 5% ±(111), (hko)..... 18%
$NaNO_3$	60	±(111)............ 5% ±(111), (100)....... 50% ±(111), (hko)....... 20% ±(111), (100), (hko). 25%	±(111).......... 65% ±(111), (hko)..... 35%
$Mg(NO_3)_2$	12	±(111)............ 28% ±(111),(100)....... 30% ±(111),(hko)....... 22% ±(111),(100),(hko).. 20%	±(111).......... 78% ±(111),(kho)..... 20% ±(111),(100),(hko) 2%
$Mg(NO_3)_2$	36	±(111)............ 12% ±(111),(100)....... 32% ±(111),(hko)....... 16% ±(111),(100),(hko).. 40%	±(111).......... 48% ±(111),(100)..... 10% ±(111),(100),(hko) 12% ±(111),(hko)..... 30%
$Mg(NO_3)_2$	60	±(111)............ 8% ±(111),(100)....... 30% ±(111),(hko)....... 32% ±(111),(100),(hko).. 30%	±(111).......... 57% ±(111),(100)..... 7% ±(111),(hko)..... 30% ±(111),(100),(hko) 6%

Lead nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$LiNO_3$	12	±(111)............ 32% ±(111), (100)....... 30% ±(111), (hko)....... 25% ±(111), (100), (hko). 23%	±(111).......... 85% ±(111), (hko)..... 8% ±(111), (100), (hko) 7%
$LiNO_3$	36	±(111)............ 15% ±(111), (100)....... 28% ±(111), (hko)....... 17% ±(111), (100), (hko). 40%	±(111).......... 50% ±(111), (100)..... 15% ±(111), (hko)..... 35% ±(111), (100), (hko) 10%
$LiNO_3$	60	±(111)............ 10% ±(111), (100)....... 35% ±(111), (hko)....... 32% ±(111), (100), (hko). 23%	±(111).......... 60% ±(111), (100)..... 10% ±(111), (hko)..... 25% ±(111),(100),(hko) 5%
KNO_3	12	±(111)............ 23% ±(111), (100)....... 35% ±(111), (hko)....... 22% ±(111), (100), (hko). 20%	±(111).......... 70% ±(111), (100)..... 5% ±(111), (hko)..... 15% ±(111),(100),(hko) 10%
KNO_3	36	±(111)............ 13% ±(111), (100)....... 32% ±(111), (hko)....... 20% ±(111), (100), (hko). 35%	±(111).......... 47% ±(111), (100)..... 20% ±(111), (hko)..... 30% ±(111),(100),(hko) 3%
KNO_3	60	±(111)............ 5% ±(111), (100)....... 30% ±(111), (hko)....... 28% ±(111), (100), (hko). 37%	±(111).......... 35% ±(111), (100)..... 15% ±(111), (hko)..... 38% ±(111),(100),(hko) 12%
$Ba(NO_3)_2$	12	±(111), (100)....... 42% ±(111), (hko)....... 30% ±(111), (100), (hko). 28%	±(111).......... 40% ±(111), (100)..... 15% ±(111), (hko)..... 40% ±(111),(100),(hko) 5%
$Ba(NO_3)_2$	36	±(111), (100)....... 35% ±(111), (hko)....... 23% ±(111), (100), (hko). 42%	±(111).......... 30% ±(111), (100)..... 25% ±(111), (hko)..... 45%
$Ba(NO_3)_2$	60	±(111), (100)....... 25% ±(111), (hko)....... 20% ±(111), (100), (hko). 55%	±(111).......... 22% ±(111), (100)..... 33% ±(111), (hko)..... 40% ±(111),(100),(hko) 5%

Barium nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$AgNO_3$	12	±(111)............ 88% ±(111), (100)....... 12%	±(111)..........100%
$AgNO_3$	36	±(111)............ 50% ±(111), (100)....... 43% ±(111), (100), (hko). 7%	±(111).......... 45% ±(111), (100)..... 20% ±(111), (hko)..... 35%
$AgNO_3$	60	±(111)............ 20% ±(111), (100)....... 45% ±(111), (100), (hko). 35%	±(111).......... 40% (100).......... 5% ±(111), (100)..... 12% ±(111), (hko)..... 43%
NH_4NO_3	12	±(111)............ 90% ±(111), (100)....... 10%	±(111)..........100%
NH_4NO_3	36	±(111)............ 48% ±(111), (100)....... 50% ±(111), (100), (hko). 2%	±(111).......... 50% ±(111), (100)..... 25% ±(111), (hko)..... 25%
NH_4NO_3	60	±(111)............ 25% ±(111), (100)....... 43% ±(111), (100), (hko). 32%	±(111).......... 47% ±(111), (100)..... 20% ±(111), (hko)..... 33%
$Ca(NO_3)_2$	12	±(111)............ 80% ±(111), (100)....... 20%	±(111).......... 80% ±(111), (100)..... 20%
$Ca(NO_3)_2$	36	±(111)............ 45% ±(111), (100)....... 53% ±(111), (100), (hko). 2%	±(111).......... 43% ±(111), (100)..... 20% ±(111), (hko)..... 37%
$Ca(NO_3)_2$	60	±(111)............ 17% ±(111), (100)....... 40% ±(111), (100), (hko). 43%	±(111).......... 50% ±(111), (100)..... 25% ±(111), (hko)..... 25%
$Cu(NO_3)_2$	12	±(111)............ 73% ±(111), (100)....... 24% ±(111), (100), (hko). 3%	±(111)..........100%
$Cu(NO_3)_2$	36	±(111)............ 45% ±(111), (100)....... 47% ±(111), (100), (hko). 8%	±(111).......... 35% ±(111), (100)..... 30% ±(111), (hko)..... 35%

Barium nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
$Cu(NO_3)_2$	60	±(111)............ 12% ±(111), (100)....... 48% ±(111), (100), (hko). 40%	±(111).......... 25% ±(111), (100)..... 37% ±(111), (hko)..... 38%
$NaNO_3$	12	±(111)............ 70% ±(111), (100)....... 25% ±(111), (100), (hko). 5%	±(111)..........100%
$NaNO_3$	36	±(111)............ 35% ±(111), (100)....... 47% ±(111), (100), (hko). 18%	±(111).......... 35% ±(111), (100)..... 30% ±(111), (hko)..... 35%
$NaNO_3$	60	±(111)............ 0% ±(111), (100)....... 40% ±(111), (100), (hko). 60%	±(111).......... 7% ±(111), (100)..... 38% ±(111), (hko)..... 55%
$Mg(NO_3)_2$	12	±(111)............ 52% ±(111), (100)....... 35% ±(111), (100), (hko). 13%	±(111).......... 92% ±(111), (100)..... 8%
$Mg(NO_3)_2$	36	±(111)............ 22% ±(111), (100)....... 55% ±(111), (100), (hko). 23%	±(111).......... 20% ±(111), (100)..... 47% ±(111), (hko)..... 33%
$Mg(NO_3)_2$	60	±(111), (100)....... 53% ±(111), (100), (hko). 47%	±(111).......... 3% ±(111), (100)..... 45% ±(111), (hko)..... 55%
$LiNO_3$	12	±(111)............ 60% ±(111), (100)....... 32% ±(111), (100), (hko). 8%	±(111)..........100%
$LiNO_3$	36	±(111)............ 28% ±(111), (100)....... 60% ±(111), (100), (hko). 12%	±(111).......... 25% ±(111), (100)..... 50% ±(111), (hko)..... 25%
$LiNO_3$	60	±(111), (100)....... 48% ±(111), (100), (hko). 52%	±(111).......... 8% ±(111), (100)..... 50% ±(111), (hko)..... 42%

Barium nitrate; Evaporation "slow"; Temperature 25°C to 30°C.

Impurity	Hours of Crystal Growth	Percent predominance	Percent dominance
KNO_3	12	±(111)............ 40% ±(111), (100)....... 47% ±(111), (100), (hko). 13%	±(111).......... 82% ±(111), (100)..... 18%
KNO_3	36	±(111)............ 17% ±(111), (100)....... 53% ±(111), (100), (hko). 30%	±(111).......... 30% ±(111), (100)..... 37% ±(111), (hko)..... 37%
KNO_3	60	±(111), (100)....... 37% ±(111), (100), (hko). 63%	±(111).......... 2% ±(111), (100)..... 33% ±(111), (hko)..... 65%

Explanation of Table No. III

An explanation of Table No. III can well be made by referring to a specific result indicated in the table. On page 262, the third horizontal column of data from the top indicates the results obtained by growing lead nitrate crystals from an aqueous solution to which some silver nitrate had been added as an impurity. Crystals were grown under conditions of "medium" rate of evaporation and at temperatures ranging from 20°C to 24°C. Observations were made after the crystals had been growing for 60 hours. The result was that 60% of the crystals were ± tetrahedrons in combination, and 40% of the crystals were ± tetrahedrons in combination with a cube. Of 75% of all the crystals the ± tetrahedrons were regarded as dominant and of 25% of all the crystals the cube was dominant. In determining the percent of dominance of ± tetrahedrons, it was considered that of crystals which were combinations of just the two tetrahedrons the tetrahedrons were dominant. These were counted in with the crystals which were combinations of ± tetrahedrons and a cube of which the tetrahedrons were dominant. The ± tetrahedrons are always considered to be equally developed. When they are not equally developed it will be indicated.

The table suggests rather strongly that the influence of the inorganic salts was determined to some extent by their relative solubility. When a salt present as an impurity is more soluble than the salt forming into crystals, the effect is to increase the tendency to form crystals of simple habit. If the salt present as an impurity is less soluble than the one whose crystals are growing the effect is to cause a tendency to form crystals of a more complex habit. Sodium nitrate, lithium nitrate, and potassium nitrate indicate a stronger influence to produce crystals of simple habit than would be expected by comparing their respective solubilities with some of of the other salts such as copper nitrate, zinc nitrate and nickel nitrate. This suggests that there is undoubtedly another property besides solubility which should be considered.

ORGANIC COMPOUNDS

In addition to the list of experiments showing the effect of inorganic salts on the habit of crystals of lead nitrate, barium nitrate, and strontium nitrate, a series of experiments was carried out in which the following organic compounds were used as impurities:

Methylene blue
Urea
Picric acid

METHYLENE BLUE

LEAD NITRATE+METHYLENE BLUE. Methylene blue was added to solutions of lead nitrate and crystals of lead nitrate were allowed to grow under the following conditions:

- Evaporation "medium"
    - Temperature 15° to 20°C.
    - Temperature 20° to 24°C.
    - Temperature 25° to 30°C.
- Evaporation "slow"
    - Temperature 15° to 20°C.
    - Temperature 20° to 25°C.
    - Temperature 25° to 30°C.

Observations of results of each of the above experiments were made for record at the end of each of the following periods of time after crystals were first observed: 12 hours, 36 hours, 60 hours.

No. 1.—Evaporation "medium"; Temperature 15° to 20°C.

All lead nitrate crystals are cubes that are formed from a solution in which a small amount of methylene blue is present as an impurity if conditions are of "medium" evaporation, and temperatures between 15° and 20° C. The crystals appear as cubes from the time they can first be seen with a 20 power binocular microscope. They continue to grow as cubes for periods of 36 and 60 hours.

No. 2.—Evaporation "medium"; Temperature 20° to 24°C.

The lead nitrate crystals formed under conditions of No. 2 begin as cubes and continue as such for a period of 12 hours. After 36 hours of crystal growth some of the crystals of the original crop are combinations of a cube and ± tetrahedrons. The cube in all cases is the dominant form. After 60 hours the pyritohedron is in combination as a decidedly subordinate form on some crystals.

No. 3.—Evaporation "medium"; Temperature 25° to 30°C.

Crystals of lead nitrate formed under conditions represented under No. 3 after the first 12 hours are a mixture of cubes and cubes in combination with ± tetrahedrons. The cube is the dominant form. Crystals of single cubes predominate in number. After 48 hours some crystals are combinations of a cube, ± tetrahedrons and a pyritohedron. The cube is still the dominant form. The pyritohedron has increased relatively in number after 60 hours of crystal growth, and is as abundant in the combination as the ± tetrahedrons.

If the above experiments are repeated by allowing "slow" evaporation in each case instead of "medium" there is no difference to be noticed in No. 1. In No. 2 there is an increase in the percent of crystals having ± tetrahedrons in combination and in No. 3 there is an increase in the percent of crystals having the pyritohedron in combination. The pyritohedron form is also relatively larger. In over 50% of the crystals it is relatively larger than the tetrahedrons.

BARIUM NITRATE+METHYLENE BLUE. STRONTIUM NITRATE+METHYLENE BLUE. The results obtained with barium nitrate and methylene blue and with strontium nitrate and methylene blue are qualitatively the same as with lead nitrate under the same conditions. In each case satisfactory results are more difficult to obtain than with lead nitrate.

Gaubert[11] has reported results with lead nitrate and methylene blue and also with strontium nitrate and methylene blue. He reports that the influence of methylene blue on crystals of these salts is to produce cubes. The results reported by him may be obtained under conditions of "fast" or "medium" rates of evaporation and temperatures of 15° to 22°C and for a period of 10 or 12 hours of crystal growth. These results are obtained with a very small amount of methylene blue in solution.

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[11] Paul Gaubert: Revue Scientifique, Paris, No. 3. Jan. 15, 1910.

Modifications in crystal habit are produced more easily with weak solutions of methylene blue than with concentrated solutions. Crystals in general are colored blue due to inclusions of the dye. The depth of color depends somewhat upon the concentration of methylene blue, and also somewhat on the rate of crystal growth. Crystals grown in a rapidly cooling solution are quite generally colorless and transparent.

Gaubert considers the cube habit to be due to the fact that the included methylene blue is arranged parallel to the cube faces. Crystals have been obtained, however, in the form of cubes that were colorless and transparent. Many crystals have also been obtained with small patches of blue scattered irregularly throughout the crystals. There seemed to be no orderly manner of arrangement. Microscopic examinations of crushed crystals show that some of the included methylene blue is faintly doubly refracting. The largest amount appears to be amorphous and with no special order of arrangement.

STRIATIONS. Crystals of lead nitrate and of barium nitrate grown from aqueous solutions containing methylene blue may show striations on the cube faces. These striations are of interest because they may occur arranged parallel to the cube edges, as in the case of pyrite, or they may occur diagonally arranged on the cube faces as in the case of sphalerite. When arranged in a diagonal manner they are parallel to the edges between faces of a tetrahedron and the cube. The striations parallel to the cube edges are, obviously, parallel to the edges between the faces of a pyritohedron and the cube.

It is of interest to note that crystals do not always show striations. When they are to be found on any of the crystals resulting from an experiment they usually occur on the majority or all of the crystals of that same experiment. Several experiments have been conducted to determine the cause of these striations and also a reason for their being arranged parallel to the edges between the cube and a pyritohedron for one set of crystals and in a diagonal manner for another set of crystals. The results obtained suggest very strongly that striations parallel to the edges between the cube and a pyritohedron are formed under conditions which would be more favorable to the pyritohedron than the cube in a pure aqueous solution. The conditions, however, are not the most favorable that are possible for the development of the pyritohedron. Three or four degrees higher temperature would be more favorable. Because of a condition in the solution produced by the presence of methylene blue the cube develops instead of the pyritohedron. There is, however, a constant tendency for the pyritohedron to form. The striations indicate the places where it existed in each case for a comparatively short time.

When crystals are allowed to develop at temperatures three or four degrees higher, in other words, at 28° to 30°C instead of 24° to 26°C, the cube faces will not be found to show striations. If crystals are allowed to grow for two or three weeks at temperatures of 28° to 30°C under conditions of "slow" evaporation, the pyritohedron will become decidedly dominant. After the first few hours of crystal growth the pyritohedron continues to grow without being interrupted.

The diagonal striations form to the best advantage at temperatures below 21°C. These temperatures are more favorable to the development of the tetrahedron than the cube in a pure aqueous solution. The conditions imposed on the solution by the presence of methylene blue, however, cause the cube constantly to interrupt the growth of the tetrahedron. The striations mark the places at which the tetrahedron had a temporary existence.

A close examination of these striations reveals the fact that they are not at all uniform in dimension. In many cases a sufficient amount of the pyritohedron faces or tetrahedron faces is present to be readily recognized.

These results corroborate the idea advanced by Wherry[12] that surface phenomena do not always indicate the symmetry or internal structure of crystals. If the symmetry of lead nitrate and of barium nitrate, as suggested by their crystal forms, is correct, there are no planes of symmetry. The striations formed on the surface of the cube faces would indicate that some crystals possess axial planes of symmetry and other crystals diagonal planes of symmetry. From this it seems that it is not safe to infer the symmetry of a crystalline substance from one type of striations. Having obtained both types, as in this case, even though they do not occur on the same set of crystals, it is evident that the true symmetry is indicated.

[12] Edgar T. Wherry: *Am. Mineral.*, 9, pp. 53–54.

The above results suggest further that the striations found on crystals occurring in nature such as are characteristic of pyrite and topaz, may be there because the temperature condition favorable to one crystal form was counteracted by the presence of impurities. Due to the presence of impurities a form developed which would not have developed ordinarily under the prevailing temperature condition. There resulted a constant struggle for existence between two forms and the striations indicate the places where one form was temporarily in existence.

UREA

The effect of urea on the crystal habit of lead nitrate, barium nitrate and strontium nitrate is to produce simple forms. During the first 36 hours after crystals have formed at temperatures of 20° to 24°C and at a "slow" rate of evaporation, the forms are more predominantly the ± tetrahedrons than would be the case in a pure aqueous solution. At the higher temperatures of 25° to 30°C and especially after 60 hours of crystal growth the crystals are of a highly complex character, with combinations of the cube, pyritohedron and ± tetrahedrons.

VISCOSITY

LEAD NITRATE+GLYCERINE. In order to determine the effect of the viscosity or of thickening of the liquid on the habit of the crystals of lead nitrate, barium nitrate and strontium nitrate, 15cc. of glycerine were added to a 25cc. solution of a salt. In each case, under conditions of "medium" evaporation and at temperatures of 20° to 25°C, at the end of 48 hours all of the crystals were combinations of a cube, ± tetrahedrons and a pyritohedron.

With lead nitrate under conditions of "medium" evaporation and temperatures above 25°C, a striking result was obtained that was not obtained with any other set of experiments. The plus and minus forms of the pyritohedron developed in combination with a cube and two tetrahedrons upon a number of crystals. These results indicate very strongly that in a liquid of high viscosity there is a strong tendency for crystals to be represented by the most complex forms possible on the substance so crystallizing, if temperature conditions are proper.

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[13] J. W. Retgers: Über den Einfluss fremder Substanzen in der Lösung auf die Form, die Reinheit und die Grösse der ausgeschieden Krystalle. *Zeit. Phy. Chem.*, 9, 267, (1892).

J. W. Retgers[13] reports that by thickening the solution through the addition of gelatine, dextrine, or glycerine, there is a tendency for the promotion of skeletal growth and satisfactory results are not obtained. The results with dextrine or sugar obtained in this work confirm Retgers' results; however, those obtained with glycerine were very satisfactory.

Allowing the solution to cool suddenly from a temperature above 25°C to a temperature below 20°C had the result of changing the habit of all the crystals (75 in number) from the complex habit to a simple habit of ± tetrahedrons. The complex forms were enclosed as phantom crystals.

BARIUM NITRATE IN AGAR-AGAR. Barium nitrate crystals were produced in agar-agar by mixing a solution of barium chloride with agar-agar and then, after the agar-agar had set as a thick gel, a solution of sodium nitrate was poured over the top. The two solutions mixed by slow diffusion. The experiment was conducted under temperature conditions above 25°C. Crystals were grouped throughout the gel in arborescent fashion and the crystals in general were considerably distorted. The forms in combination on practically all of the crystals after crystal growth had been going on for a period of five weeks were ± tetrahedrons as the dominant forms, and a pyritohedron. On some crystals the cube had also developed. The crystals in general were tabular in development.

LEAD NITRATE+SUSPENSIONS. The effect of a fine suspension on crystal habit was determined by using magnesium oxide, powdered alundum, powdered kaolinite, and powdered barite. These experiments did not give the results expected. From the results obtained with glycerine it was predicted that a suspension of a fine powder in a solution of either of the nitrates used would have the effect of causing the crystals to become more complex. This, however, was not the case. The crystals produced with lead nitrate at temperatures up to 24°C even at a slow rate of evaporation were all ± tetrahedrons in combination, equally developed. The tendency is for a smaller number of crystals to form and therefore the crystals produced are larger. The powdered substance was included in all the crystals but was not arranged in any orderly fashion. The distribution was in patches arranged in an irregular manner. No explanation is offered for the results obtained.

DISCUSSION

By way of review it may be mentioned that in general in the study of crystal habit by far the greatest amount of effort seems to have been directed to determine the influence of foreign substances. There seems to have been very little consideration given to control conditions for crystal growth, even to considering the possible influence of such conditions. Very little consideration seems to have been given to the nature of the impurity, to the temperature at which crystal growth takes place and not a great deal to the rate of crystal growth.

The explanations advanced to account for the influence of foreign substances, are based on (1) adsorption, (2) capillarity, and (3) inclusion of the foreign substance into the crystal in a definite manner.

The experiments presented in this paper have been conducted under conditions controlled to a certain extent. The conditions under which the crystals developed were very carefully noted and recorded. The nature of the impurity has been taken into consideration and considerable attention has been given to temperature conditions. An effort has also been made to determine by means of X-ray study, if impurities actually enter into the crystal structure.

There may be cases where adsorption has in some way, not yet fully understood, influenced crystal habit. The results obtained in a large number of experiments point very strongly to the conclusion that this is not always the case. If adsorption were regarded as the cause for the formation of the cube in connection with certain dyes present in a solution of lead nitrate, barium nitrate or strontium nitrate, one would meet with difficulties in explaining results that may be obtained at a temperature of 30°C. If crystals are allowed to grow rapidly at that temperature as has been pointed out, the combination of ± tetrahedrons results. If the solution while remaining at this same temperature is suddenly transferred to conditions where "slow" crystal growth takes place, pyritohedrons will develop, instead of a cube, in combination with the two tetrahedrons. Furthermore, perfect cubes of each of the three salts studied have been obtained from solutions in which some methylene blue was present, which were entirely free from color.

Also, allowing crystals to grow in the presence of methylene blue at 20°C and then slowly increasing the temperature and finally changing to"slow" rate of evaporation, the crystals will change in habit from cubes to combinations of cubes and pyritohedrons and also cube, pyritohedrons and ± tetrahedrons. The fact that crystals may be brought to change in habit in a pure aqueous solution by changing the temperature of crystal growth suggests that the nature of the solvent may have some relation to crystal habit.

Water in an aqueous solution is considered to have different properties than water alone. This has been suggested by the fact that there is a difference in transparency of water in a solution and water in which no substance is dissolved. The modification in crystal habit may possibly be due, in at least some cases, to the nature of the solvent instead of to a peculiar condition existing at the surface of some of the crystal faces by virtue of adsorption of the foreign material. The effect of the nature of the solvent has been clearly demonstrated in some organic compounds, where substances may be produced as needle-like crystals from one solvent and as flaky or tabular crystals from another solvent.

In reviewing further the results obtained with inorganic salts as impurities, it is quite striking that the effect of a foreign substance is intimately related to its solubility. There is sufficient evidence by way of variation in results to suggest that other properties besides the solubility enter into the action to influence crystal habit. The results obtained with ammonium nitrate for instance suggest that viscosity is a property which should be considered.

Also, the salts of elements entering into alkaline and basic compounds (K, Na, Ca, Mg) show a stronger tendency to produce crystals of a simple habit than would naturally be expected by considering their solubilities. Jenkins[14] in considering the velocity of crystallization of urea, acetanilide and ammonium nitrate in various solvents reports that the viscosity of the solution is an important factor.

In considering the effect of inorganic impurities it seems evident that impurities of greater solubility than the salt crystallizing out, increase the rate of crystal growth especially during the first twenty-four hours of crystal development. Ammonium nitrate is known to produce the effect of lowering the viscosity of solutions and the effect of the presence of ammonium nitrate as an impurity to produce simple forms is most marked. In the light of the results reported by Jenkins, it may be concluded that the effect of ammonium nitrate is actually to increase the rate of crystal growth. Hence allowing some for effect of viscosity, it may be regarded, in general, that the effect of inorganic salts is to increase or decrease the rate of crystal growth, depending upon the relative solubility.

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[14] John D. Jenkins: *J. Am. Chem. Soc.*, **47**, No. 4, April, 1925.

The outstanding factors influencing crystal habit seem to be temperature and rate of crystal growth. Of the two, temperature decidedly seems to be the controlling condition. In the light of the theories of Federov, Schönflies and Barlow, partitioning space into space unites or space lattices, or elementary cells which have been substantiated by X-ray studies of crystal structure, it seems quite reasonable to assume that crystal habit is intimately related in some way to crystal structure.

X-RAY PHOTOGRAPHS. It seems reasonable to assume that if foreign substances enter into intimate relation with the atoms or molecules as has been suggested there might be a change in the size of the unit cells, and consequently a change in the space relations of the structure planes. However, a comparison of powder photographs, made by Dr. L. S. Ramsdell of the University of Michigan, showing on the same film diffraction patterns of crystals from pure aqueous solutions and of crystals of the same salt obtained from aqueous solutions containing impurities revealed no difference in structure or in dimensions of the unit cell.

CONCLUSIONS

For every crystalline substance there are possible certain crystal forms. The forms possible may be considered to be determined by the crystal structure. Considering, then, that there is a constant tendency of a crystal surrounded by a liquid medium containing its own substance to reach a state of equilibrium with respect to its immediate surroundings, one particular form may approach a state of equilibrium for a specific condition or set of conditions, more easily than any other form. Several important factors which make up the conditions to which the crystal reacts are: (1) temperature; (2) nature of solvent; (3) presence of foreign particles; (4) viscosity; (5) rate of crystal growth.

When forms are in combination it means the conditions have successively changed, or that the conditions prevailing during the time of crystal growth were not exactly the most favorable for either but a fairly close approach and the forms developed simultaneously, each struggling for existence. If we understood solutions more completely and had a more definite knowledge of the shape of the structural units a more satisfactory explanation of crystal habit might possibly be formulated.

NOTE ON ZARATITE FROM BOHEMIA, PENNSYLVANIA AND TASMANIA

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In the carboniferous formation of central Bohemia, millerite is a rather frequent mineral in the cavity fillings of sideritic septaria, and in geodes and veinlets in the arkoses and other sediments. The localities are numerous: Rapice, whence millerite was first mentioned by Em. Bořický, Kladno, Jemníky, Pchery, Motyčín, Dubí, and Libušín. The last locality has furnished a specimen now in the National Museum, which on a surface of about 40x20 cm. carries a dense felt of millerite needles, some of them over 4 cm. in length. The millerite and other sulphides are constantly associated with older ankerite and earthy nacrite, frequently also with barite and whewellite crystals, which are the youngest members in the paragenesis.

Nearly twenty years ago, the late professor Adolf Hofmann, of the Příbram School of Mines, brought to Prague from the Praga mine, near Dubí, specimens of millerite which were covered with a very thin film of an emerald-green secondary mineral. The nacrite aggregates in the vicinity are also impregnated and colored by the same alteration product of millerite. It was recognized as zaratite but chemical proof was not possible as the millerite needles were firmly inter-grown with the siderite matrix.

Last autumn I obtained through the kindness of Mr. J. Hummel, mining engineer at Motyčín (Ronna mine) several magnificent specimens of siderite concretions with millerite tufts in their septaria. These were freely developed in the cavities with single millerite needles[1] two centimeters and more in length. Many of them show a splendid emerald-green surface due to a very thin film of a secondary mineral.

On these samples, the carbonate material of the alteration product has been established and the green mineral is really zaratite, as had been supposed. An entirely satisfactory optical examination of the zaratite from Motyčín was not possible as the films are so thin that flat lying particles of them appear in the microscope quite isotropic and only where they have remained on millerite crystals and the light passes through a thicker part along the borders can a feeble birefringence be observed. The whole coating on a single millerite needle is optically uniform and the direction parallel to the vertical axis of the millerite is positive. The refractive index varies within the limits 1.565 to 1.566.

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[1] Very rarely beyrichite has been found also in the same paragenesis.

If we compare these observations with the hitherto known data on zaratite, a considerable variation in this mineral becomes manifest; the colloidal and metacolloidal hydrated carbonate of nickel behaves in the same manner as those of magnesium and zinc. Like hydromagnesite with the related minerals, and like hydrozincite, the zaratite seems to include different substances both amorphous and cryptocrystalline, which represent different stages in the development from gels to crystalline aggregates.

In the work of Mr. E. S. Larsen on the Microscopic Determination of Non-opaque Minerals, zaratite is mentioned (p. 158) as an isotropic mineral; the sample used by him was from the Wood mine, Texas, Lancaster Co., Pennsylvania, and showed a banded structure and a refractive index varying within the broad limits from 1.56 to 1.61.

In the collections of the Mineralogical Department of Charles University at Prague, there are zaratite specimens from two known localities; from the Wood mine, and from Hazelwood in Tasmania. On the sample from the Wood mine the zaratite forms a thin minute mammillary crust on chromite. Microscopically it consists of spherocrystals or of thin layers, the fibers of which are orientated perpendicular to the surface, as in malachite or thermal aragonite. The extinction is parallel to the elongation of the fibers, which have an optically positive sign. The double refraction is moderate, the refractive indices vary within rather wide limits: in some fibers the refraction both parallel and perpendicular to the length is higher than 1.56, while in others in parallel orientation it reaches about 1.562. Perpendicular to the length it is a little lower than 1.559. Only a small admixture of amorphous material could be observed in the zaratite powder in our specimen, its index of refraction is approximately 1.56.

In the powder preparations of the zaratite from Hazelwood the amorphous constituent is not so scarce as in the sample from the Wood mine. The isotropic substance shows a lighter green color than the fibrous one. Its refractive index is 1.565. The fibers of the spherocrystals and the parallel aggregates show a distinct though feeble pleochroism: parallel to the length the absorption is stronger and the color emerald-green, perpendicular thereto a lighter, slightly yellowish green. The extinction is always parallel to the length. The mean refractive index is higher than in the Pennsylvania specimen and is variable but near 1.589.

OPTICAL NOTES ON SOME MINERALS FROM THE MAHOPAC IRON MINE, BREWSTER, NEW YORK

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INTRODUCTION

In May, 1925, the writer, accompanied by several students, visited the dumps of the old Tilly Foster and Mahopac Iron Mines, near Brewster, New York. The mineralogy of the two mines seems to be very similar, although the material collected from the dump of the Mahopac mine did not contain examples of all of the minerals that have been reported from the Tilly Foster mine. Not having opportunity to carry the study further it seemed of value to describe the minerals that were collected since no tabulation of the minerals from the Mahopac Mine has ever been published. The importance of the study of these minerals is increased by the fact that the optical properties of most of the unusual varieties of the minerals from the similar Tilly Foster mine have not been recorded.

LOCATION OF THE MAHOPAC MINE

The Mahopac iron mine is located on the west side of Lake Mahopac and at the north end of a small lake called Kirk Lake, in Putnam County, New York. The mine is about seven miles southwest of the Tilly Foster mine. Its exact location is shown on the map of the West Point quadrangle published by the U. S. Geological Survey. It is near the east margin of the map on the road between Mahopac Falls and Kent Cliffs. All that is now visible of the mine is a small pond occupying the caved-in portion.

LITERATURE

Owing to the similarity in mineralogy of the Mahopac and Tilly Foster Mines, descriptions of the one are of interest in the study of the other. Several detailed descriptions of the geology and of the ore deposits of the two mines have been published. The latest of these, and one in which the older literature is summarized, is that of Colony[1] but in none of these reports is a detailed description given of the interesting mineralogy of the ore and its gangue.

The list of the minerals found at these mines, and reference to their published descriptions is given by Whitlock[2]. The only mineral cited by him as occurring at the Mahopac Mine is magnetite, although 28 minerals are listed from the Tilly Foster mine. Breidenbaugh[3] gave one of the first descriptions of these minerals. He described the mica, the chlorite, two varieties of serpentine, enstatite, actinolite, three varieties of chondrodite, pyrite, chalcopyrite, pyrrhotite, calcite, quartz, fluorite, and apatite. A year later J. D. Dana[4] described the serpentine pseudomorphs of the Tilly Foster mine. He said[5] that chondrodite, enstatite, hornblende, ripidolite, massive chlorite, dolomite, biotite, apatite and calcite, and two other species not yet determined occur changed to serpentine. In his preliminary remarks he gave interesting information in regard to mineral associations.

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[1] Colony, R. J.; The magnetite iron deposits of southeastern New York: *New York State Museum Bull.*, **249–250**, pp. 121–126 (1923).

A little later E. S. Dana[6] published the results of a careful crystallographic study of the chondrodite from the same mine, and in another paper he[7] gave the results of an optical study to show that the mineral was monoclinic and not orthorhombic.

Analyses of the chondrodite from the Tilly Foster mine were given by Penfield and Howe[8] in their study of the humite group.

Other mention of the gangue minerals of the ore has been by name only. Ruttman[9] writing in 1887, listed the minerals from the Tilly Foster mine as follows: brucite, calcite, chondrodite (ruby colored crystals), dolomite, enstatite, epidote, fluorite, magnesite, magnetite, marcasite, molybdenite, muscovite, chlorite, pyrite, pyroxene, pyrrhotite, serpentine, talc and green garnet.

Koeberlin[10] who made a careful study of the geology of the district, found that the ore from the Tilly Foster mine contained

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[2] Whitlock, H. P.; List of New York mineral localities: *New York State Museum Bull.*, **298**, pp. 68–71 (1903).

[3] Breidenbaugh, E. S.; On the minerals found at the Tilly Foster iron mines, N. Y.: *Amer. Jour. Sci.*, (3) **6**, pp. 207–13 (1873).

[4] Dana, J. D.; On serpentine pseudomorphs from the Tilly Foster iron mine: *Amer. Jour. Sci.*, (3) **8**, pp. 371–381, and 447–459 (1874).

[5] *Idem.* p. 457.

[6] Dana, E. S.; On the chondrodite from the Tilly Foster iron mine, Brewster, New York: *Amer. Jour. Sci.*, (3), **10**, pp. 89–103 (1875).

[7] Dana, E. S.; On the optical character of the chondrodite of the Tilly Foster mine, Brewster, New York: *Amer. Jour. Sci.*, (3), **11**, pp. 139–140 (1876).

[8] Penfield, S. L. and Howe, W. T. H.; On the chemical composition of chondrodite, humite and clinohumite: *Amer. Jour. Sci.*, (3), **47**, pp. 188–206 (1894).

[9] Ruttman, F. S.; Notes on the geology of the Tilly Foster ore body, Putnam Co., N. Y.: *Trans. Amer. Inst. Min. Eng.*, **15**, p. 89 (1887).

[10] Koeberlin, F. R.; The Brewster iron bearing district of New York: *Econ. Geology*, **4**, p. 740 (1909).

only magnetite, chondrodite, spinel and serpentine. These he had noted in one thin section.

Colony[11], the most recent writer, said:

> "None of the earlier students of this (the Tilly Foster) deposit seemed to attach any importance to the unusual minerals in the ore, such as chondrodite, ripidolite, brucite, serpentine, spinel, and allied types. The magnetite replaces a previously metamorphosed interbedded crystalline limestone; connected with the ore are still unreplaced remnants of colorless pyroxene, both monoclinic and orthorhombic, (essentially diopside and enstatite); an almost colorless olivine, chondrodite, light green spinel, phlogopite, clinochlore and serpentine."

Of the Mahopac Mine he[12] said:

> "Samples of material from the old dump carry chondrodite, clinohumite, clinochlore, phlogopitic colorless mica, carbonate, serpentine and magnetite."

Boydell[13] made a study of the splendid collection of serpentine pseudomorphs from the Tilly Foster mine in the Harvard Mineralogy collection, but his material has not been published.

Larsen[14] has given the optical data on a chondrodite from Brewster, N. Y.

THE MINERALS FROM THE MAHOPAC MINE

CHONDRODITE. Two varieties of chondrodite were found among the specimens collected by the writer. Crystals in white marble have a deep golden brown color, while others associated with chlorite, amphibole and magnetite, have a deep red color, similar to that shown by some garnets, yet the optical properties of the two varieties are nearly identical. The red variety has a slightly smaller optic angle than the brown. According to Penfield and Howe[15] the garnet red crystals from the Tilly Foster mine contain 7.22% FeO while the brown crystals contain only 5.94% FeO.

The optical properties of the chondrodite were determined to be as follows:[16]

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[11] Colony, R. J.; The magnetite iron deposits of southeastern New York: *New York State Museum Bull.*, **249–250**, pp. 122–123 (1923).

[12] Colony, R. J.; *op. cit.*, p. 125.

[13] Boydell, H. C.; Unpublished manuscript presented as a partial requirement in a course in the paragenesis of minerals, Harvard University, 1920.

[14] Larsen, E. S.; The microscopic determination of the non-opaque minerals' *U. S. Geol. Survey Bull.*, **679**, p. 57 (1921).

[15] Penfield, S. L. and Howe, W. T. H.; *op. cit.*, pp. 194-197.

[16] In all determinations of refractive indices here given the accuracy is ± .003.

$\alpha=1.643$	$2V=80° \pm 5°$ (brown crystals).	Pleochroism strong:
$\beta=1.655$	$2V=75° \pm 5°$ (red crystals).	X=deep chrome yellow;
$\gamma=1.670$	$\rho > \nu$ moderate.	Y=yellow;
	Polysynthetic twinning common.	Z=light yellow.
	Optic sign +.	

These properties are very similar to those of a variety of chondrodite given by Larsen[17] but the refractive indices are higher than on the variety he studied from Brewster, N. Y.

Olivine. Although Colony was the first to mention the occurrence of olivine at these mines, it is in reality one of the most abundant minerals not only at the Mahopac mine, but also at the Tilly Foster. The mineral has a light green color on a fresh surface, but where weathered the color is yellow or yellow brown. The olivine is associated with amphibole, chondrodite, chlorite and magnetite.

The optical properties of the olivine are as follows:

$\alpha=1.673$	2V near 90°.	Optic sign, +(?).
$\beta=1.688$	$\rho > v$ weak.	
$\gamma=1.704$		

These properties are not those of forsterite, the usual olivine found in contact metamorphosed limestones, but are rather those of a variety containing more iron.

Spinel. Spinel is a very common mineral at the Mahopac mine, although most of the crystals are so small that they are found only during the microscopic study of the specimens. The spinel is black, or very dark green in color by reflected light, and when in euhedral crystals has the octahedral form common to that mineral.

It is a variety of pleonaste with an index of refraction of 1.759, and has a deep grass green color by transmitted light.

Chlorite. Chlorite is commonly associated with the chondrodite, and the deep green color of the chlorite makes a striking contrast to the dark brown or red of the chondrodite.

The optical properties are as follows:

$\alpha=1.580$	$2V=0°$ to 12°.	Optic sign, +.	Symmetrical extinction on polysynthetic twinning in sections containing X and Z, 3 degrees.
$\beta=1.581$	$v > \rho$ weak.	Pleochroism faint,	
$\gamma=1.590$		X=faint green,	
		Z=colorless.	

This is presumably the ripidolite mentioned by Colony.[18]

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[17] Larsen, E. S., *Op. cit.*, p. 291.

[18] Colony, R. J.; *Op. cit.*, p. 123.

PYROXENE. Only one pyroxene was found in the material collected by the writer. It occurs in cleavable masses associated with magnetite and mica, and except that the optic angle is large it has properties similar to diopside.

The properties are as follows:

$\alpha = 1.679$ $\beta = 1.691$ $\gamma = 1.705$	2V 80°±5°. $\rho > v$ weak.	Optic sign, +. Color, green. Cleavage, typical pyroxene.	Extinction angle, $c \wedge Z = 29°$. Not pleochroic, but green in thick grains.

MICA. A greenish mica occurs in sub-hedral crystals, reaching an inch in diameter, associated with pyroxene and magnetite. It has a pearly luster on the cleavage flakes, and a light greyish-green color. The color along a very pronounced gliding or parting plane (probably 102) is very dark green. The plates have a wavy structure as was noted by Breidenbaugh[19] on the mica from the Tilly Foster mine.

The optical properties are as follows:

$\alpha = 1.558$ $\beta = 1.595$ $\gamma = 1.595$	2V, nearly 0°. Optic sign, −.	Pleochroism, X = nearly colorless, Z = pale green in thick flakes.

These properties are nearer those of muscovite than of phlogopite, as the mineral was called by Colony.[20]

AMPHIBOLES. Two varieties of the amphibole group were found. One has unusual optical properties, although it resembles actinolite in the hand specimen. Cleavage faces of massive aggregates associated with magnetite have the color of actinolite but in the marble it occurs as small dark green crystals with corroded edges.

The properties of this green amphibole are as follows:

$\alpha = 1.634$ $\beta = 1.644$ $\gamma = 1.655$	2V = 85°. $v > \rho$ perceptible.	Optic sign, +. Cleavage, typical amphibole. Extinction angle $c \wedge Z = 24°$. $b = Y$.	Pleochroism, weak, X = slate grey, Y = yellow green, Z = blue green.

The other amphibole occurs in large cleavable masses, individual grains of which reach several inches in diameter. It is associated with tourmaline, apatite, quartz, and scapolite, minerals not found associated with the chondrodite, olivine, spinel and chlorite.

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[19] Breidenbaugh, E. S.; *Op. cit.*, p. 208.

[20] Colony, R. J.; The magnetite iron deposits of southeastern, New York: *New York State Museum Bull.*, **249–250**, p. 125 (1923).

The optical properties are as follows:

$\alpha=1.651$ $\beta=1.659$ $\gamma=1.674$	$2V=75°\pm5°$. $\rho>v$ weak. Extinction angle $c\wedge Z=22°$	Optic sign, −. Cleavage, typical of amphibole. Color, black.	Pleochroism, strong, X=light yellow green; Y=green; Z =deep blue green

Scapolite. Scapolite occurs only with the black amphibole, and with quartz, tourmaline and apatite. It is a colorless, glassy variety and is moderately altered to an isotropic mineral having an index of refraction of about 1.48. The indices of refraction of the scapolite are: $\epsilon=1.542$ and $\omega=1.560$.

Tourmaline. Small black crystals of tourmaline occur with the black amphibole and in quartz; $\epsilon=1.632$; and $\omega=1.663$. The pleochroism is strong from a light cinnamon brown, with a tinge of red; to very dark green.

Apatite. Only microscopic crystals of apatite occur. The indices of refraction are 1.632 and 1.637.

Serpentines. Insufficient material was available to study these minerals and no properties can be given.

BOOK REVIEWS

GEOLOGICAL MAPS. The Determination of Structural Detail. Robert M. Chalmers. Oxford University Press, American Branch, *New York*. **1926**. vi+175 pp., with folder and numerous illustrations. Price 12s. 6d. net, postage extra. ($4.25.)

The subtitle expresses well the purpose of this book which has been written primarily for students. After a brief discussion of topography, the author treats in detail the effect of the inter-relationship of topography and structure upon the distribution of outcrops. Numerous problems on the determination of thickness of beds, strike, dip, direction and amount of throw and heave of faults, etc., are presented and solved mathematically. This feature of the book should make it especially valuable to beginning students in geology. All geological maps referred to are of British areas but the manner of treatment is such that this fact does not detract from the value of the book for American students.

Chas. W. Cook.

ROCKS AND ROCK MINERALS. Louis V. Pirsson, revised by Adolph Knopf. Second edition. 426 pages. $3.50 net. John Wiley & Sons, Inc., *New York*.**1926**.

The first edition of this excellent text on the megascopic determination of rocks appeared in 1908. In the second, the revised edition but minor changes can be noted. No single portion has received any notable contribution of new material. The cuts, figures and analyses are the same as in the previous text, but in places material has been transposed and short paragraphs omitted to make space for a few new rock terms and descriptions to give the book a modern appearance.

The table giving the megascopic classification of igneous rocks is now expanded to include such transitional types as quartz monzonite, monzonite, granodiorite and latite. While the book has been brought up-to-date in certain directions the portion dealing with the formation of pegmatites and the discussion of differentiation are essentially the same as in the earlier edition. Expansions at these points so as at least to include Bowen's theory would have seemed very desirable.

The book in its present form, with slightly larger page and better quality of paper, produces a very favorable impression and no doubt will continue to remain one of the most popular texts in its particular field. W.F.H.

NOTES AND NEWS

LAUMONTITE FROM SOUTHERN OREGON

H. W. McClellan, *Massachusetts Institute of Technology*

A few months ago some samples of supposed gold ore from near Grants Pass, Oregon, were sent in by a prospector, and although they proved of little value for their gold content, they were interesting because of the occurrence of laumontite in them.

The locality from which the specimens came is about 26 miles northeast of Grants Pass, in the foothills of the Cascade Mountains, in a region of serpentine rocks. The so-called ore came from a crushed and faulted zone which had allowed the circulation of solutions, and the laumontite occurs filling small veins and cavities in the serpentine. The country rock itself has been very little altered.

The mineral is pure china white in color, with silky lustre, but under the microscope it appears brownish, due probably to impurities. It does not occur in distinct crystals, but shows an excellent cleavage parallel to the *c*-axis, causing a fibrous character in this direction. The principal cleavage faces developed are parallel to $\{110\}$, and to a lesser degree parallel to $\{100\}$.

A sample of high purity was analyzed by Mr. Earl V. Shannon, of the U. S. National Museum at Washington, whose results are here compared with two analyses taken from Dana's "System of Mineralogy."

	Grants Pass, Ore.	Port George, N. S.	Table Mt., Colo.
SiO_2	50.64	51.43	52.07
Al_2O_3	21.86	21.64	21.30
CaO	12.18	12.07	11.24
MgO	0.74	——	——
K_2O	1.34	——	0.42
Na_2O	0.42	——	0.48
H_2O above 110°C	12.01	15.26	14.58
H_2O below 110°C	1.58		
	100.77	100.40	100.09

The physical constants were determined as follows: Sp.gr. 2.23; H=3–4; Monoclinic. Optically negative. Optic plane parallel to *b*. $X\Lambda c=+50°$. Dispersion $\rho<\nu$. Indices: $\alpha=1.505\pm.003$; $\gamma=1.513\pm.003$.

In comparing with data in Dana's System of Mineralogy, it is found that this laumontite has lost some of its water, and has slightly more potassium and somewhat less silica than any for which the analyses are given. Likewise the angle $X\Lambda c$ is only 50° instead of 65° to 70°.

Dr. W. L. Uglow, M. A., B. Sc. (Queens), Ph.D. (Wisc.), Professor of Mineralogy and Petrography, University of British Columbia, died at Vancouver, Aug. 3rd. He was injured while bathing at Honolulu on his way home from Hongkong. He had just finished a field season on geological work for the Chinese Government. He was formerly on the staff of the University of Minnesota and had had experience in Peru, in Ontario with the Bureau of Mines and in British Columbia with the Geological Survey of Canada. Last year he was awarded the Leonard medal by the Canadian Institute of Mining and Metallurgy for the best paper presented before the Society.

Announcement has been received of the death of Frederick A. Canfield, Dover, New Jersey. His collection of minerals, it is stated, has been left to the U. S. National Museum.

According to *Science News* a chrome ore deposit, said to be one of the largest in the world, has been discovered near Columbus, Montana, on the edge of Yellowstone National Park. Professor J. F. Kemp of Columbia University, after an examination in company with representatives of the U. S. Geological Survey, announced that this discovery is of great importance not only because of the rust-resisting properties of chromium steel alloys, but also because chromium is rapidly replacing nickel in the electroplating industry.

Professor William James Lewis, late professor of mineralogy at the University of Cambridge and senior fellow of Oriel College, Oxford, who died on April 16, bequeathed to the Mineralogical Museum, Cambridge, such of his books and apparatus as his successor may select; the balance to be offered to Bedford College for Women, London.

A gold deposit thought to be of large proportions has been discovered at Boliden, in the province of Vesterbotten not far from the Arctic Circle, according to Dr. Axel Gavelin, head of the Swedish Geological Survey. Besides gold the ore contains silver, copper, sulphur, arsenic and iron. Electrical prospecting methods are said to be responsible for the find as the ore bodies are covered by glacial drift, swamps or lakes.